CLAIMS

1. An LED device comprising:

a light emitting semiconductor;

a transparent lens covering said semiconductor and spaced apart therefrom; and

a phosphor layer contained within or coated on an inside or outer surface of said lens.

2. An LED device according to claim 1, wherein said inside surface of said lens has a surface area at least ten times the exposed surface area of the light emitting semiconductor.

3. An LED device according to claim 1, further comprising a transparent filler positioned between said light emitting semiconductor and said lens.

4. An LED device according to claim 3, wherein said transparent filler is an optical coupling material which may be an epoxy, silicone, acrylic, thermoplastic, urethane, polyimide or an index modified matching fluid or gel.

5. An LED device according to claim 4, wherein said filler has an refractive index closely matching the geometric mean of the refractive index of said light emitting semiconductor and said lens material.

6. An LED device according to claim 1, wherein said phosphor layer has a substantially uniform thickness.

7. An LED device according to claim 1, wherein said phosphor layer is formed from a slurry comprising one or more phosphors and a binder.

8. An LED device according to claim 1, wherein said phosphor layer is formed from a slurry comprising one or more phosphors, a scattering medium and a binder.

9. An LED device according to claim 7, wherein said slurry may contain a carrier solvent and said binder is a transparent refractive index matching material.

10. An LED device according to claim 9, wherein said solvent is methyl ethyl ketone and said binder is selected from the group consisting of silicone, acrylic, epoxy, thermoplastic and polyimide.

11. An LED device according to claim 1, wherein said phosphor layer comprises one or more of $Y_3Al_5O_2$:Ce, $Tb_3Al_{4.9}O_{12}$:Ce, $Sr_4Al_{14}O_{25}$:Eu, and mixtures thereof.

12. An LED device according to claim 1, wherein said light emitting semiconductor is a blue emitting LED or a UV emitting LED having a primary emission in the range of 200-480 nm.

13. An LED device according to claim 1, wherein said LED device emits white light.

14. An LED device according to claim 1, having a package efficiency of 70% or greater.

15. An LED device according to claim 1, wherein said lens comprises a sphere or hemisphere and said light emitting semiconductor is positioned at the center of said sphere or hemisphere.

16. An LED device comprising:

a light emitting semiconductor;

a transparent lens covering said semiconductor and positioned apart from the light emitting semiconductor by a distance at least about two times the length of a longest side of said light emitting semiconductor; and

a phosphor layer contained within or coated on an inside or outer surface of said lens.

17. An LED device comprising

a light emitting semiconductor;

a reflector supporting said light emitting semiconductor;

a transparent lens covering said semiconductor and said reflector and spaced apart from said semiconductor; and

a uniform thickness phosphor layer coated on at least a portion of said reflector and contained within or coated on an inside or outer surface of said lens.

18. An LED device according to claim 17, further comprising a reflective layer positioned between said phosphor layer and said reflector.

19. An LED device according to claim 18, wherein said reflective layer comprises a high dielectric powder.

20. An LED device according to claim 17, further comprising a submount on which said semiconductor is mounted, wherein said submount is also coated with said phosphor layer.

21. An LED device according to claim 17, wherein said phosphor layer is from 6 to 100 μm thick.

22. An LED device according to claim 17, wherein said semiconductor is a blue or UV emitting LED in the range of 200-480 nm.

23. An LED device according to claim 17, having a package efficiency of 70% or greater.

24. An LED device according to claim 17, wherein said LED chip is free of said phosphor coating.

25. A method for forming an LED device having a lens with a uniform phosphor coating, said method comprising the steps of:

providing an LED mounted on a support;

providing a transparent lens sized to fit over or around said support;

depositing a uniform thickness phosphor coating on a surface of said lens;

assemblying said LED, mount and lens to form said LED device.

26. A method according to claim 25, wherein said step of depositing said phosphor on said lens comprises the substeps of:

forming a slurry comprising phosphor powder, a solvent and a binder;

optionally heating said lens to a temperature above room temperature;

stamping, screening, dispensing, rolling, brushing or spraying said slurry onto said lens to achieve a uniform thickness coating layer; and

curing said binder to form a permanent coating layer.

27. (Cancel).

28. (Cancel).

29. (Cancel).

30. (Cancel).

31. An LED device comprising:

a plurality of light emitting semiconductors mounted on a reflective electrical interconnect board;

a transparent lens covering said semiconductors and spaced apart from said semiconductors; and

a phosphor layer contained within or coated on an inside or outer surface of said lens.

32. An LED device according to claim 31 in which said lens has a refractive index matching a refractive index of said light emitting semiconductors for improved light extraction and chip protection

33. A LED device according to claim 31, wherein said plurality of light emitting semiconductors comprise blue LEDs, said device further comprising a band pass light filter positioned on said lens between the phosphor layer and said blue LEDs, said band pass filter functioning to pass the emission wavelength of the LEDs and reflect the emission wavelength of the phosphor layer.

34. A LED device according to claim 31, wherein said plurality of light emitting semiconductors comprise UV LEDs, said device further comprising a first band pass light filter positioned on said lens between the phosphor layer and said blue LEDs, for passing the emission wavelength of the LEDs and reflecting the emission wavelength of the phosphor layer, and a second band pass light filter positioned on an exterior surface of said lens for passing the emission wavelength of the phosphors and reflecting the emission wavelength of the LEDs.

35. A LED device according to claim 31 in which an array of micro or macro lenses is formed on the outer surface of the lens to control the emission angle, direction or intensity of the emitted radiation.

36. A LED device according to claim 31 in which the lens is easily detachable from said LED device such that additional lenses containing different phosphor mixes or amounts can be installed to easily adjust the light color temperature, CIE and CRI without changing the light emitting semiconductors.